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Instruction Manual
for the
Twin Transistor Power Supply
Type AS1164.2

THE SOLARTRON ELECTRONIC GROUP LTD.

Farnborough Hampshire England

SOLARTRON

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for the
Twin Transistor Power Supply
Type AS1164.2

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CONTENTS.

Section.		Page.
1	Specification	1
	General Description.	1
	Output Voltages	1
	Output Current.	1
	Regulation.	1
	Stability...	1
	Ripple and Noise	1
	Ambient Temperature Rating..	1
	Output Impedance	1
	Chassis Isolation	1
	Overload Protection System...	2
	A.C. Supply Requirements	2
	Dimensions and Weight ..	2
2	Operating Instructions	2
	Front Panel Controls	2
	Operation (General).	3
	Seperate Operation .	3
	Series Operation	4
	Parallel Operation..	4
	Operational Notes ..	4
3	Circuit Description .	4
	General...	4
	Transformer...	4
	Rectifier..	5
	Limiter Resistor	5
	Series Element	5
	The Feedback Network...	5
	The Control Amplifier	5
	Overload Protection.	6
	Ancillary Supplies...	6
4	Setting-Up and Test Procedure	7
	Test Equipment	7
	Preliminary Tests..	7
	Mains Voltage Selector Panel .	7
	Load Sharing...	8
	Transformer Tap Selection	8
	Setting-Up Limiters.	8
	Performance Checks	9
	Regulation against Mains Variation.	9
	Regulation against Load Changes...	9
	Recover Time..	10
	Miscellaneous Checks	10
	Appendix I Pulse Amplifier TG 48..	11
5	Components Lists ..	12
	Resistors...	12
	Resistors Variable	14
	Capacitors..	15
	Semiconductors..	15
	Miscellaneous	17

ILLUSTRATIONS AND DIAGRAMS.

		Page
Frontispiece	The Twin Power Supply Type AS1164.2	IV
Figure.		
1	Block Diagram AS1164.2	5
2	Simplified Overload Control System	6
3	Regulation Test Circuit	9
4	Impedance Test Circuit	9
5	Recovery Time Test Circuit	10
6	Circuit Diagram (Pulse Amplifier TG 48)	11
7	Components Location (Rear View)	18
8	Components Location (Underside View)	19
9	Components Location (Group Boards 1, 2 and 3)	19
10	Components Location (Board No 4)	20
11	Circuit Diagram AS1164.2	Inside Rear Cover

Frontispiece The Twin Power Supply Type **AS1164.2**

SECTION 1.

SPECIFICATION.

GENERAL.

The twin transistor power supply consists of two separate supplies, each with individual controls, mounted in the same case. By means of a guarded switch, the two channels may be used in parallel, with voltage control automatically transferred to the right hand channel. An external link may be used so that the two supplies can be operated in series. A fully electronic proportional control system of overload protection is provided which is self resetting except when the supply is operated in the series condition when the self resetting facility does not operate for load currents in excess of 40% of the limiter setting.

OUTPUT VOLTAGE.

Two outputs, each variable from 0 - 30 V by decade switches providing steps of 10, 1, and 0.1 V. The accuracy of voltage setting at room temperature-off load is ± 2%, + 2 mV.

OUTPUT CURRENT.

Up to 1 Amp may be drawn from each of the outputs. Output current meters of grade 1 accuracy are provided in each channel, linked terminals are available into which an external meter may be connected.

REGULATION.

The variation in output voltage, for a change in output current from 0 - full load at the maximum voltage setting of 30 V, is less than 30 mV, i.e. 0.1%.

STABILITY.

The change in output voltage caused by a change in supply of ± 7% is typically 2 mV and always less than 5 mV. (Stability factor greater than 1000 : 1).

RIPPLE AND NOISE.

Typically 1 mV peak-to-peak. (less than 2 mV peak-to-peak).

AMBIENT TEMPERATURE RATING.

The power supply will work at ambient temperatures up to 35°C with no restriction on use. Provided overload conditions are not allowed to persist for longer than 5 minutes on any occasion, the unit may be worked in ambient temperatures up to 45°C.

OUTPUT IMPEDANCE.

Nominally 0.5 ohms up to 100 kc/s.

CHASSIS ISOLATION.

The supplies may be operated with the output terminals at potentials up to ± 250 V with respect to chassis. A maximum potential of 500 V can exist between the two supplies.

OVERLOAD PROTECTION SYSTEM.

Self-resetting, proportional control - fully electronic. The maximum current output, i.e. the point at which the overload circuit becomes operative, may be set independently on each supply to any one of six spot values of nominally 1 Amp, 0.5 Amp, 250 m Amp, 100 m Amp, 50 m Amp, and 25 m Amp.

A.C. SUPPLY REQUIREMENTS.

100 - 125 V and 200 - 250 V a.c. 50 - 60 c/s.

DIMENSIONS.

14.5/8 ins. long x 7.5/16 ins. wide x 11.3/8 ins. high overall.
(36.5 cms. x 18.5 cms. x 28.8 cms.)

WEIGHT.

25 lbs. approximately.
(11.33 kg)

SECTION 2.

OPERATING INSTRUCTIONS.

FRONT PANEL CONTROLS.

The front panel controls are considered in three groups as follows :

1) Those controls relating to output 1.

2) Those controls relating to output 2.

3) Those controls relating to both supplies.

Viewing the front panel from the front, group 1 is on the left, group 2 on the right and group 3 in the centre. The controls in group 2 are a mirrored image of those in group 1 and will not be described.

DECADE VOLTS.

Three switches in a vertical line on the extreme left of the panel. These control the output voltage of output 1 in steps of 10, 1 and 0.1 volts.

N.B. During parallel operation, the voltage output of both supplies is controlled by the Decade Volts controls of output 2 (extreme right of panel). The output 1 controls do not operate.

OVERLOAD.

An indicator on the left centre of the front panel which is lit when the overload limiter is operating. This is associated with a switch which presets the load current at which the limiter comes into operation.

O/P1 - ON.

The output switch which isolates the positive output terminal from the power supply.

MAINS - ON.

The supply switch which controls the a.c. supply to the transformer primary.

SEPARATE.

An indicator lamp which is lit when the two supplies are set for independent operation.

SEP - PAR.

A two position switch to determine the operating mode of power supply viz. Separate or parallel.

PARALLEL.

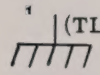
An indicator lamp which is lit when the two supplies are set for parallel operation.

O/P1.

The terminals from which output 1 is taken (separate operation only). The red terminal is the positive pole of the supply.

O/P2.

The terminals from which output 2 is taken. The red terminal is the positive pole of the supply.



(TL5) A terminal which connects to chassis.

OPERATION.

When the instrument first arrives, check it for superficial damage. Set the mains voltage selector panel to the stated nominal local supply voltage. Check that the fuse rating is correct for the supply voltage in use viz :-

200 - 250 V - 2.5 A

100 - 125 V - 5 A

Connections to the power supply and adjustments of the controls will vary according to the mode of operation of the supply. The remainder of these instructions will therefore be written under three sections corresponding to separate, series, and parallel operation.

SEPARATE OPERATION.

This mode of operation is used when one or two loads have to be supplied at different potentials and different currents. The voltage across each load cannot exceed 30 volts and the current through each load must be less than 1 Amp. Set the SEP/PAR switch to SEP; connect the loads to the output terminals as required; set the decade voltage switches to the required output potential. Estimate the maximum current which can be drawn by the load without damage to it, and set the relevant overload selector switch to a suitable range.

Switch on the a.c. mains, observe that the 'separate' lamp is lit. Switch O/P1 and O/P2 as required, check that neither overload indicator is lit. Where a common line exists between the two loads, the relevant terminals of the supply may be commoned.

SERIES OPERATION.

Where a single load is to be supplied at a potential between 30 and 60 V, the two supplies may be connected in series by connecting the positive pole of output 2 to the negative pole of output 1. The load is then connected between the positive pole of output 1 and the negative of output 2.

Set the SEP/PAR switch to SEP and adjust the decade voltage selectors so that the sum of the six control settings is equal to the required voltage.

Set both overload selector switches to the maximum safe output current. Switch on the supply main and check that the SEP light is lit. Then switch on O/P1 and O/P2. Either of these switches will switch off the supply. Both meters should read the output load current. Check that neither overload indicator is lit.

PARALLEL OPERATION.

Where a single load is to be supplied at a potential between 0 - 30 V requiring currents between 1A and 2A the two supplies may be used in parallel. Connect the load between one pair of terminals. Control the output by the relevant output switch.

Set the SEP/PAR switch to PAR and adjust the decade voltage selector of output 2 to give the required output voltage. Set the two overload selectors such that the sum of the two settings is the required limiter setting.

Switch on the a.c. supply and check that the 'parallel' light is lit. Switch on the output. The load current is the sum of the readings on the two meters.

OPERATIONAL NOTES.

The output voltage may be changed when the power supply is in operation on load. The limiter current selector may be adjusted when the power supply is in operation on load. If the limiter comes into operation on either supply, the relevant overload lamp will light, and remain lit until the overload is removed or the limiter current selector adjusted. If the limiter fails to reset* when the overload is removed, switch off the power supply, or switch off the output switch, pause, then switch on again.

* series operation only.

SECTION 3.

CIRCUIT DESCRIPTION.

GENERAL.

The twin transistor power supply type AS 1164 consists of two similar supplies each capable of delivering 30 volts at 1 Amp stabilised. These supplies may be operated separately, in series, or in parallel. The output voltage of each supply is controlled by three switches, the first providing ten volt steps ; the second, one volt steps ; the third, 0.1 volt steps. A fourth switch associated with each supply presets the output load current at which the automatic limiter action comes into operation. Each output is independently switched. When the supplies are operated in parallel the controls of Output 2 override those of Output 1 and take over control of both supplies. The positive or negative poles of either supply may be earth referred to TL5.

TRANSFORMER.

The input from the a.c. supply main, passes through a supply switch and fuse into a mains voltage selector panel and on to the primary of the transformer. The primary is wound in two equal tapped halves for operation from 110 volt or 220 volt a.c. supplies. The tappings are arranged to accept any voltage from 100 to 125 volts in 5 volt steps, or from 200 to 250 volts in 10 volt steps.

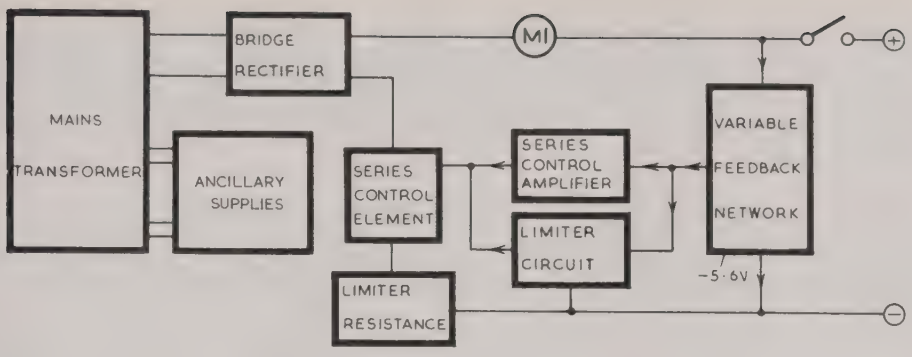


Figure 1. Block Diagram AS1164.2

The transformer has six secondary windings, three relating to output two, and three relating to output one. The first secondary provides the main power for output two, it is tapped and the taps are selected by wafers of the output voltage switches. S2A selects one of three taps according to the setting of the 10 V output voltage switch. S3A selects one of two taps according to the setting of the units volts switch. The second and third windings provide ancillary supplies required for the control amplifier of output two. The fourth, fifth and sixth secondaries are similar to the first, second and third secondaries, but relate to output one.

RECTIFIER.

The output from secondary one, is taken through the tap changing switches on to a bridge rectifier MR11-MR14. The rectified a.c. is then smoothed by the reservoir capacitor C2. The resistors R10 and R11 provide a discharge path across C2. The positive rectified voltage is then passed through a link across which an external meter can be connected if required, through the internal meter, and to the positive output terminal through the output switch S6.

LIMITER RESISTOR.

The load current returns to the supply through the negative terminal and passes immediately to the limiter resistor. This resistor, selected by S4, determines the current at which the limiter comes into operation. Preset currents of 25, 50, 100, 250 or 500 m A or of 1 Amp may be selected.

SERIES ELEMENT.

The series control element consists of three transistors VT4, VT5, and VT6, connected in parallel as a multiple emitter follower. They are driven on their bases by the emitter follower VT3.

THE FEEDBACK NETWORK.

The negative feedback network consists of R47-R67, R45, R46 and RV2. The resistors R47-R67 are connected in series from positive HT line to R45 and are shorted out by the switches S2/C, S3/C and S5 to vary the feedback ratio and therefore the output voltage. The lower end of the resistor chain is connected to a reference potential between -5.6 V and HT negative determined by the setting of RV2 and the resistors R45 and R46. C10 provides compensation for inductive pick-up in the delay network.

CONTROL AMPLIFIER.

The control amplifier consists of four transistors connected as two emitter coupled differential amplifiers in cascade. The first pair consists of VT9 and VT10, VT10 receives signal from the negative feedback chain on its base while VT9 is referred to a potential approximating to HT negative, and determined by the setting of RV1. R43 and C7 connected between the bases of VT9 and VT10 are incorporated to improve the transient response of the supply. They integrate any transient change in line voltage and slow down the rate of change of voltage at the base. The outputs from the collectors of VT9 and VT10 are directly coupled to the bases

of VT11 and VT12, two N.P.N. transistors. The collector of VT11 is connected directly to HT negative and the collector of VT12 connects through a load to +6.5 volts. The series-connected R-C network (C21 and R138) between the collector of VT12 and common rail provides loop stability by preventing undue variations in phase shift, thereby giving an improved output impedance characteristic. The output from the amplifier is taken from the collector of VT12 directly to the base of VT3.

OVERLOAD PROTECTION.

The power supply is protected from overload by a limiter stage with proportional control, this circuit is the subject of a patent application. The system of overload control is as follows:- When the emitter follower is connected with a fixed resistance in the emitter circuit and fixed-base potential, the current drawn through the transistor cannot exceed the value at which the IR drop in the emitter resistor exceeds the base potential.

A simple system of over current protection would therefore be to catch the base potential of the series element so that it could not fall below the level, which would give rise to an excess current into the output load. This method of protection however could lead to power over loading of the series element when the severity of the overload became great so that the whole of the reservoir capacitor potential appeared across the series element. To overcome this disadvantage the circuit which is used varies the voltage to which the base of the series element is clamped according to the severity of the overload. Thus in the presence of a short circuit across the output, the series elements are held back to a safe power dissipation.

A simplified circuit of the overload system is shown in Fig. 2. The base potential of the series element VT4, VT5, and VT6 in parallel, is normally controlled by the output voltage from the collector of VT12, through the emitter follower VT3, and will move more negatively as more power is demanded from the power supply. The emitter of VT7 is connected to the base of VT3. Under normal conditions this transistor is cut off. When the base of VT3 moves sufficiently negative that an overload current would flow, the emitter of VT7 moves more negative than its base. VT7 then conducts, clamping the base potential of VT3 to the base potential of VT7. The base potential of VT7 is set up by adjusting RV3 to make VT7 conduct at the required preset overload currents.

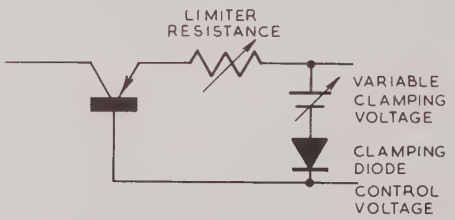


Figure 2. Simplified overload Control System.

R33 in the resistor chain containing RV3, is connected to the collector of VT8 which is connected on its base through R29 to the feedback resistors. In the presence of overload conditions on the supply, the voltage across the output terminal will tend to collapse making the base of VT10 and that of VT8 move negatively. This will cause the collector of VT8 to move more positive, reducing the negative voltage at the base of VT3 and thereby reducing the current through the series element. Thus the current output from the supply will be reduced as the severity of overload is increased. This enables the main series element to work at nearly constant power dissipation.

VT25 is the overload indicator switch, it consists of a transistor which is switched when the limiter transistor VT7 commences to conduct. VT25 then conducts, causing current to flow through the indicator lamp LP3.

ANCILLARY SUPPLIES.

The a.c. output from the second secondary of the transformer is rectified by MR1 and MR2 and smoothed by R1 into the reservoir capacitor C1. This supplies a negative unstabilised voltage for the collector of VT3. The a.c. output from the third of the transformer secondary windings feeds two rectifier systems, one producing a positive output and the other a negative output. The positive output is smoothed by C5 and feeds the base of the series control element. The positive supply is then stabilised by the Zener diode MR9 fed through R6 to provide a positive 6.5 volt rail which supplies parts of the series control amplifier.

The output from the negative rectifier system is smoothed on the reservoir capacitor C4 and provides current to drive the overload indicator lamp LP3 and the transistor VT25. The remainder of the output from this supply is stabilised by the series control element VT1 controlled by the amplifier VT2. The stabilised

negative 10 volt output provides current for sections of the control amplifier and overload circuitry. It also feeds through R9 to the Zener diode MR10 which provides a -5.6 volts reference potential. Variations in the -10 volt line are fed to the base of VT2 through the resistor chain R7, R8. The emitter of VT2 is referred to HT negative through the Zener diode MR8. Control signals are taken from the collector of VT2 to the base of the series control element VT1.

The second power supply output 1 is similar in most respects to that which has just been described, except that the component reference numbers vary. The tap changing switches are duplicated, one set being connected to the output voltage controls of output 1, these are operational when two of the supplies are used independently. A second set of tap changing switches are ganged to the output controls of output two and come into operation when the two supplies work in parallel. Under these conditions the amplifier and overload circuits of output one are isolated by the separate/parallel switch S12.

SECTION 4.

SETTING UP AND TEST PROCEDURE.

GENERAL.

The information which follows is abstracted from the factory test procedure. The instrument leaves the factory fully set up and should not require further adjustment unless major repair work has been undertaken, or any of the preset controls has inadvertantly been moved or replaced. The following test equipment is required to carry out the tests :-

TEST EQUIPMENT.

Variable Voltage Transformer 0 - 250 volts, 50 c/s (Variac).
A general Purpose Oscilloscope (Solarscope CD 513).
Voltmeter Multi-range (Avometer Model 8).
An Auxiliary Stabilised Power Supply (Solartron AS 757.2).
A Load Resistor, 500 ohms Variable, 1 Amps rating.
Voltmeter 0 - 30 volts d.c., 0.3% accurate (Electronic Instruments Ltd.)
An Oscillator 25 c/s - 500 kc/s (Solartron CO 546).
Paper Capacitor 16 Microfarads, 600 volts.
Resistor High Stability, 1000 ohms, 1% (Erie Type 109).
Insulation Tester, e.g. Megger 500 volts.
Load resistor, 15 ohms variable, 5 Amps rating.
Pulse Generator (Solartron GO 1101).
Pulse Amplifier (Solartron TG48).

PRELIMINARY TESTS.

Insulation.

Before connecting the instrument to the a.c. supply, set all toggle switches to ON and set S12 to SEP. Use the Megger to check the insulation between chassis and OP1, chassis and OP2, OP1 and OP2. The insulation resistance must not be less than 10 megohms, check the insulation between the mains line terminal and chassis, between the mains line terminal and output 1, and between the mains line terminal and output 2. The insulation must not be less than 100 megohms.

MAINS VOLTAGE SELECTOR PANEL.

Set the mains voltage selector panel on the instrument to 250 volts, connect the mains lead from the instrument to the Variac and connect the Variac to the supply mains. Set the Variac to 250 volts and switch on the Variac and the instrument. Use the d.c. multi-range voltmeter to measure the d.c. voltage across C4, which should be approximately 23 volts. Select in turn all 10 positions of the mains voltage selector panel, in

each case adjusting the Variac to provide the required input voltage. Check that the voltmeter reading across C4 is the same ± 0.7 volts. Reset the mains selector and the Variac to 250 volts. Set all the decade voltage switches to zero and the current limiter selectors to 1 Amp. Turn RV3 and RV8 fully clockwise. Using the multi-range voltmeter connected across the terminals of output 1, and adjust RV6 for zero output, then connect the voltmeter across the terminals of output 2, and adjust RV1 for zero output. Use the 50 micro amp range for final adjustments of each supply. Connect the sub-standard voltmeter on the 20 volt range across the terminals of output 2. Set the decade voltage switches of output 2, to 10, 9, 1 and adjust RV2 to give 20 volts reading on the meter. Connect the meter to the terminals of output 1, set the decade voltage switches of output 1 to 10, 9, 1 and adjust RV7 to give a reading of 20 volts on the meter. Check the output voltage at all positions of each of the three decade switches on each of the two outputs. The voltage must be within ± 2% of nominal. Monitor to -10 V line with the CRO and adjust RV4 and RV5 for minimum ripple.

LOAD SHARING.

Set the decade voltage selectors of both supplies to 10, 9, 1 and switch S12 to parallel. Set the mechanical zero's of the internal meters. Connect the 15 ohms load resistor across the terminals of output 2, and reduce the resistance until the load current is 2 Amps. The two internal meters must read within 50 mA of each other.

TRANSFORMER TAP SELECTION.

Remove all loads from the power supply. Connect the sub-standard voltmeter to measure the a. c. voltage applied to the bridge rectifier MR11-MR14 and then to the bridge rectifier MR26-MR29. Set S3 to 0 V and S2 to 0 V, note the voltage reading. Set S2 to 10 and 20, and then set S3 to 5; on each change of S2 or S3, note the new a. c. voltage. These should correspond to the voltages given in the following table. Turn S12 to SEP and repeat the measurements across MR26-MR29 adjusting S7 and S8.

TABLE 1.

Limiter Setting.	Ext. Meter Reading.
1 A	1.145 - 1.265 A
500 mA	575 - 635 mA
250 mA	290 - 320 mA
100 mA	119 - 131 mA
50 mA	62 - 68 mA
25 mA	33 - 37 mA

SETTING UP LIMITERS.

Set the decade switches to deliver an output voltage of 0.1 volts from each supply and place a short circuit across the terminals of output 1. Adjust RV8 so that the internal meter reads 0.6 Amps. Connect the sub-standard meter to the external meter socket of output 1. Remove the short circuit from the terminals of output 1 and replace them by the 15 ohms load resistance. Increase the output voltage until the overload lamp is lit, read the current on the sub-standard meter, reduce the voltage back to zero and set the limiter current selector in turn to each of its other 5 positions. In each case increase the voltage until the limiter overload indicator is lit and check that the current lies within those limits set out in the following table. If necessary, readjust RV8 and re-check. Ensure the lamp does not light up on any range until the current indicated on the limiter switch has been exceeded. Replace the load by a short circuit and set decade switches to 20, 9, 1, the current registered on the internal meter should not exceed 0.5 Amps demonstrating that the proportional control transistor VT20 is operating correctly. Repeat the setting up on output No. 2, using RV3 to set the overload current limit for this output.

TABLE 2.

Decade Switch Setting.	R. M. S. Voltage Across Rectifiers.
0 V	11.5 V
10 V	20.5 V
20 V	29.5 V
25 V	34 V

PERFORMANCE CHECKS.

Unless otherwise stated each of the performance checks which follows must be done in turn on both supplies.

Ripple and Noise.

Set the decade voltage selectors to 20, 9, 1, set the current limiter selector to 1 Amp, connect the 500 ohms resistor across the output terminals and set it to draw a load current of 1 Amp. Adjust the Variac so that the mains voltage supply to the unit is 7% low. Connect the cathode ray oscilloscope across the output terminal and check that the ripple and noise does not exceed 2 mV peak-to-peak. Apply this check to both output channels.

REGULATION AGAINST MAINS VARIATION.

Set up the test gear as shown in Fig. 3. Set the output voltage to 20, 9, 1 and adjust the backing off supply to give a convenient reading on the Avometer, set on the 50 micro amp range. Arrange the load resistor to draw 1 Amp from the supply, vary the mains voltage from -7% to +7% of nominal. The total change in output must not exceed 5 mV.

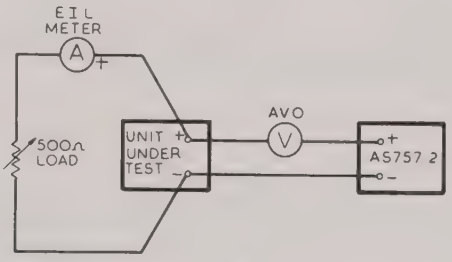


Figure 3. Regulation Test Circuit.

REGULATION AGAINST LOAD CHANGES.

With the test gear arranged as in Fig. 3. set the a.c. supply to nominal and back off the output as in the previous test. Measure the change in output voltage for a change from zero to 1 Amp load current. The change in output voltage must not exceed 30 mV.

OUTPUT IMPEDANCE.

Re-arrange the test equipment as shown in Fig. 4. and set the load current to 0.5 Amps. Set the cathode ray oscilloscope to the 10 mV/cm range, vary the oscillator frequency between 25 c/s and 100 kc/s. The display on the cathode ray oscilloscope must not exceed 15 mV peak-to-peak. Apply this check to both output channels.

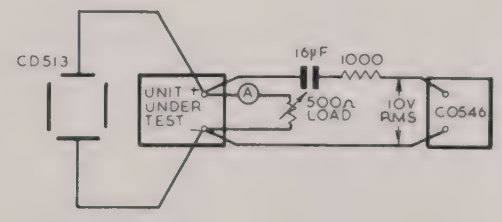


Figure 4. Impedance Test Circuit.

RECOVERY TIME.

Set up the test equipment as shown in Fig. 5. Adjust both decade switches to 10, 0, 0; set the pulse generator pulse-width to 20μsecs and period to 40μsecs, adjust the output level to 2V, and the CRO time-base speed to 10μsecs/cm. Measure the recovery time of each output channel, this time must not exceed 5μsecs.

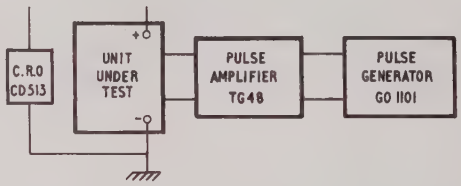


Figure 5. Recover Time Test Circuit.

METER ACCURACY.

Check the accuracy of both panel meters at fullscale deflection at current loadings of 0.2, 0.4, 0.6, 0.8 and 1.0 Amp. Panel meter accuracy should be within ± 3% of FSD.

MISCELLANEOUS CHECKS.

Switch off the mains supply and use the Avo model 8 on the 100 ohms range, across the output terminals to measure the forward conduction of MR15 and MR16. The positive terminal of the Avo should be connected to the positive terminal of the supply. The Avo should read approximately 20 ohms.

With no load connected to the output terminals, connect the Avometer, set on the 10 mA range, across the external meter sockets at the rear of the instrument. There should be a standing current of 5 mA. Check that the red sockets are a positive polarity.

Solartron Pulse Amplifier TG 48 used for checking the pulse response of the power supply.

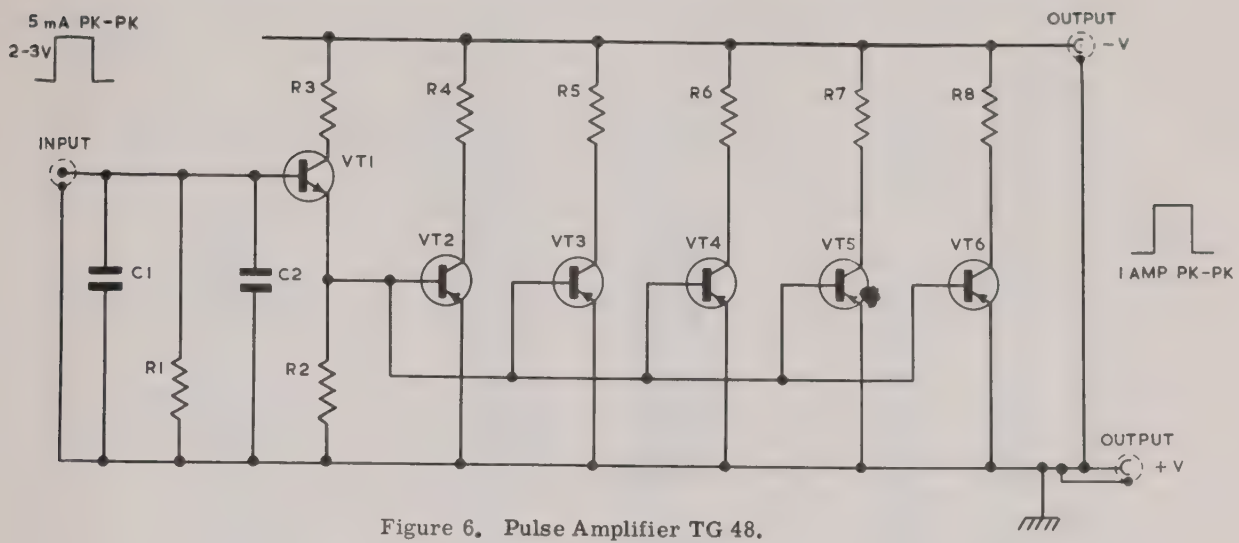


Figure 6. Pulse Amplifier TG 48.

Resistors		Capacitors	Transistors
R_1	1kΩ ($\frac{1}{4}$ watt)	C1 - C2 0.1μF	VT1 - VT6 type TK31C (Texas Instruments)
R_2	15Ω ($\frac{1}{4}$ watt)	125V Wima	
R_3-R_8	47Ω (2 watt)		

NOTE : All resistors must be non-inductive.

The input pulse is derived from a Solartron Pulse Generator GO 1005. The terminals XY are connected to the positive and negative terminals respectively, of the power supply under test.

SECTION 5.

COMPONENTS LIST

RESISTORS.

Circuit Ref.	Value Ohms	Tol. %	Rating Watts	Solartron Part No.	Manufacturer & Type	
R1	10	10	1/4	226301	Erie	16 Carbon
R2	1000	10	1/4	226325	Erie	16 Carbon
R3	220	10	1/4	226317	Erie	16 Carbon
R4	1800	10	1/4	226328	Erie	16 Carbon
R5	1000	10	1/4	226325	Erie	16 Carbon
R6	1500	10	1/2	226527	Erie	8 Carbon
R7	1200	1	1/4	223044	Painton	72 H.S.
R8	2200	1	1/2	223650	Painton	73 H.S.
R9	390	2	1/2	223832	Painton	73 H.S.
R10	4700	10	1/2	226533	Erie	8 Carbon
R11	4700	10	1/2	1725 34700	Erie	8 Carbon
R12	1800	10	1/4	1723 31800	Erie	16 Carbon
R13	18K	10	1/4	1723 41800	Erie	16 Carbon
R14	18K	10	1/4	1723 41800	Erie	16 Carbon
R15	6800	10	1/4	1723 36800	Erie	16 Carbon
R16	6.3	2	1/2	N22588	Painton	73 H.S.
R17	6.3	2	1/2	N22588	Painton	73 H.S.
R18	6.3	2	1/2	N22588	Painton	73 H.S.
R19	1500	10	1/2	226527	Erie	8 Carbon
R20	6.3	2	1/2	N22588	Painton	73 H.S.
R21	6.3	2	1/2	N22588	Painton	73 H.S.
R22	6.3	2	1/2	N22588	Painton	73 H.S.
R23	5.1	2	1/4	N22607	Painton	72 H.S.
R24	1.17	2		N22590	Painton	72 H.S.
R25	5.1	2	1/4	N22607	Painton	72 H.S.
R26	7.5	2	1/4	N22586	Painton	72 H.S.
R27	12	2	1/4	N22587	Painton	72 H.S.
R28	20	1	1/4	223001	Painton	72 H.S.
R29	1.5K	2	1/2	223846	Painton	73 H.S.
R30	2200	2	1/2	223850	Painton	73 H.S.
R31	1500	2	1/2	223846	Painton	73 H.S.
R32	300	1	1/2	223829	Painton	73 H.S.
R33	3900	1	1/2	223856	Painton	73 H.S.
R34	15K	10	1/4	226339	Erie	16 Carbon
R35	1000	10	1/4	226325	Erie	16 Carbon
R36	1000	10	1/4	226325	Erie	16 Carbon
R37	22K	10	1/4	226341	Erie	16 Carbon
R38	1000	1	1/2	223842	Painton	73 H.S.
R39	4700	5	1/2	223858	Painton	73 H.S.
R40	5600	5	1/2	223860	Painton	73 H.S.
R41	5600	5	1/2	1708 35600	Painton	73 H.S.
R42	1800	5	1/2	1708 31800	Painton	73 H.S.
R43	68	10	1/4	1723 16800	Erie	16 Carbon
R44	8200	10	1/4	1723 38200	Erie	16 Carbon
R45	4.7K	1	1/2	1707 34700	Painton	93 H.S.

RESISTORS. (Cont'd).

Circuit Ref.	Value Ohms	Tol. %	Rating Watts	Solartron Part No.	Manufacturer & Type	
R46	1.3K	1	$\frac{1}{2}$	1707 31300	Painton	93 H.S.
R47	2000	1	$\frac{1}{2}$	1707 32000	Painton	93 H.S.
R48	2000	1	$\frac{1}{2}$	1707 32000	Painton	93 H.S.
R49	200	1	$\frac{1}{4}$	1704 22000	Painton	92 H.S.
R50	200	1	$\frac{1}{4}$	1704 22000	Painton	92 H.S.
R51	200	1	$\frac{1}{4}$	223025	Painton	72 H.S.
R52	200	1	$\frac{1}{4}$	223025	Painton	72 H.S.
R53	200	1	$\frac{1}{4}$	223025	Painton	72 H.S.
R54	200	1	$\frac{1}{4}$	223025	Painton	72 H.S.
R55	200	1	$\frac{1}{4}$	223025	Painton	72 H.S.
R56	200	1	$\frac{1}{4}$	223025	Painton	72 H.S.
R57	200	1	$\frac{1}{4}$	223025	Painton	72 H.S.
R58	20	1	$\frac{1}{4}$	223001	Painton	72 H.S.
R59	20	1	$\frac{1}{4}$	223001	Painton	72 H.S.
R60	20	1	$\frac{1}{4}$	223001	Painton	72 H.S.
R61	20	1	$\frac{1}{4}$	223001	Painton	72 H.S.
R62	20	1	$\frac{1}{4}$	223001	Painton	72 H.S.
R63	20	1	$\frac{1}{4}$	223001	Painton	72 H.S.
R64	20	1	$\frac{1}{4}$	223001	Painton	72 H.S.
R65	20	1	$\frac{1}{4}$	223001	Painton	72 H.S.
R66	20	1	$\frac{1}{4}$	223001	Painton	72 H.S.
R67	20	1	$\frac{1}{4}$	223001	Painton	72 H.S.
R68	6800	10	$\frac{1}{4}$	226335	Erie	16 Carbon
R69	Not fitted					
R70	Not fitted					
R71	10	10	$\frac{1}{4}$	226301	Erie	16 Carbon
R72	1000	10	$\frac{1}{4}$	226325	Erie	16 Carbon
R73	220	10	$\frac{1}{4}$	226317	Erie	16 Carbon
R74	1800	10	$\frac{1}{4}$	226328	Erie	16 Carbon
R75	1000	10	$\frac{1}{4}$	226325	Erie	16 Carbon
R76	1500	10	$\frac{1}{2}$	226527	Erie	8 Carbon
R77	1200	1	$\frac{1}{4}$	223044	Painton	72 H.S.
R78	2200	1	$\frac{1}{2}$	223650	Painton	73 H.S.
R79	390	2	$\frac{1}{2}$	223832	Painton	73 H.S.
R80	4700	10	$\frac{1}{2}$	226533	Erie	8 Carbon
R81	4700	10	$\frac{1}{2}$	226533	Erie	8 Carbon
R82	1800	10	$\frac{1}{4}$	226328	Erie	16 Carbon
R83	Not fitted					
R84	Not fitted					
R85	Not fitted					
R86	6.3	2	$\frac{1}{2}$	N22588	Painton	73 H.S.
R87	6.3	2	$\frac{1}{2}$	N22588	Painton	73 H.S.
R88	6.3	2	$\frac{1}{2}$	N22588	Painton	73 H.S.
R89	1500	10	$\frac{1}{2}$	226527	Erie	8 Carbon
R90	6.3	2	$\frac{1}{2}$	N22588	Painton	73 H.S.
R91	6.3	2	$\frac{1}{2}$	N22588	Painton	73 H.S.
R92	6.3	2	$\frac{1}{2}$	N22588	Painton	73 H.S.
R93	5.1	2	$\frac{1}{4}$	N22607	Painton	72 H.S.
R94	1.17	2		N22590		H.S. W.W.
R95	5.1	2	$\frac{1}{4}$	N22607	Painton	72 H.S.

RESISTORS. (Cont'd).

Circuit Ref.	Value Ohms	Tol. %	Rating Watts	Solartron Part No.	Manufacturer & Type	
R96	7.5	2	1/4	N22586	Painton	72 H.S.
R97	12	2	1/4	N22587	Painton	72 H.S.
R98	20	1	1/4	223001	Painton	72 H.S.
R99	1.5K	2	1/2	223846	Painton	73 H.S.
R100	2200	2	1/2	223850	Painton	73 H.S.
R101	1500	2	1/2	223846	Painton	73 H.S.
R102	300	2	1/2	223829	Painton	73 H.S.
R103	3900	2	1/2	223856	Painton	73 H.S.
R104	15K	10	1/4	226339	Erie	16 Carbon
R105	1000	10	1/4	226325	Erie	16 Carbon
R106	1000	10	1/4	226325	Erie	16 Carbon
R107	22K	10	1/4	226341	Erie	16 Carbon
R108	1000	2	1/2	223842	Painton	73 H.S.
R109	4700	2	1/2	223858	Painton	73 H.S.
R110	5600	2	1/2	223860	Painton	73 H.S.
R111	5600	2	1/2	223860	Painton	73 H.S.
R112	1800	2	1/2	223848	Painton	73 H.S.
R113	68	10	1/4	226311	Erie	16 Carbon
R114	8200	10	1/4	226336	Erie	16 Carbon
R115	4.7K	1	1/2	1707 34700	Painton	93 H.S.
R116	1.3K	1	1/2	1707 31300	Painton	93 H.S.
R117	2000	1	1/2	223649	Painton	73 H.S.
R118	2000	1	1/2	223649	Painton	73 H.S.
R119	200	1	1/4	223025	Painton	72 H.S.
R120	200	1	1/4	223025	Painton	72 H.S.
R121	200	1	1/4	223025	Painton	72 H.S.
R122	200	1	1/4	223025	Painton	72 H.S.
R123	200	1	1/4	223025	Painton	72 H.S.
R124	200	1	1/4	223025	Painton	72 H.S.
R125	200	1	1/4	223025	Painton	72 H.S.
R126	200	1	1/4	223025	Painton	72 H.S.
R127	200	1	1/4	223025	Painton	72 H.S.
R128	20	1	1/4	223001	Painton	72 H.S.
R129	20	1	1/4	223001	Painton	72 H.S.
R130	20	1	1/4	223001	Painton	72 H.S.
R131	20	1	1/4	223001	Painton	72 H.S.
R132	20	1	1/4	223001	Painton	72 H.S.
R133	20	1	1/4	223001	Painton	72 H.S.
R134	20	1	1/4	223001	Painton	72 H.S.
R135	20	1	1/4	223001	Painton	72 H.S.
R136	20	1	1/4	223001	Painton	72 H.S.
R137	20	1	1/4	223001	Painton	72 H.S.
R138	820	10	1/4	172328200	Erie	16 Carbon
R139	820	10	1/4	172328200	Erie	16 Carbon

RESISTORS VARIABLE.

RV1	250	10	1/2	256408	Colvern	CLR1206/9S W.W.
RV2	10K	10	1/2	256413	Colvern	CLR1206/9S W.W.
RV3	500	10	1/2	256409	Colvern	CLR1206/9S W.W.
RV4	250K	20	1/8	N25067	Morganite	LPV Carbon
RV5	250K	20	1/8	N25067	Morganite	LPV Carbon

RESISTORS VARIABLE (Cont'd).

Circuit Ref.	Value Ohms	Tol. %	Rating Watts	Solartron Part No.	Manufacturer & Type	
RV6	250	10	½	256408	Colvern	CLR1206/9S W.W.
RV7	10K	10	½	256413	Colvern	CLR1206/9S W.W.
RV8	500	10	½	256409	Colvern	CLR1206/9S W.W.

CAPACITORS.

Circuit Ref.	Value µFd	Tol. %	Rating Volts	Solartron Part No.	Manufacturer & Type	
C1	250	-20 +100	6	2611 92500	Hunts	MEW101T. El.
C2	2500	-20 +50	50	2611 92500	Hunts	KB112AT. El.
C3	Not fitted					
C4	250	-20 +100	25	N20456	Hunts	MEF35T. El.
C5	250	-20 +100	25	N20456	Hunts	MEF35T. El.
C6	4	-20 +50	150	N20279	TCC	CE132FC El.
C7	0.22	10	125	N20490	Wima	M. Poly.
C8	500	-20 +50	50	N20262	TCC	CE26DE. El.
C9	16	-20 +50	150	2616 71600	Hunts	MEF112T. El.
C10	1	20	250	N20234	Hunts	AM105 MPl.
C11	250	-20 +100	6	N20454	Hunts	MEW101T. El.
C12	2500	-20 +50	50	2611 92500	Hunts	KB112AT. El.
C13	Not fitted					
C14	250	-20 +100	25	N20456	Hunts	MEF35T. El.
C15	250	-20 +100	25	N20456	Hunts	MEF35T. El.
C16	4	-20 +50	150	N20279	TCC	CE132FC. El.
C17	0.22	10	125	N20490	Wima	M. Poly.
C18	500	-20 +50	50	N20262	TCC	CD26DE. El.
C19	16	-20 +50	150	2616 71600	Hunts	MEF112T. El.
C20	1	20	250	N20234	Hunts	AM105 MPl.
C21	0.005	-20 +40	500	N20254	Erie	K3500/81/BD.Cc.
C22	0.005	-20 +40	500	N20254	Erie	K3500/81/BD.Cc.

SEMI CONDUCTORS.

Circuit Ref.	Description	Solartron Part No.	Manufacturer & Type	
VT1	Transistor		Mullard	OC 84
VT2	Transistor		G.E.C.	GET 874
VT3	Transistor		S.T.C.	TK 31
VT4	Transistor		Mullard	OC 36
VT5	Transistor		Mullard	OC 36

SEMI CONDUCTORS. (Cont'd).

Circuit Ref.	Description	Solartron Part No.	Manufacturer & Type	
VT6	Transistor		Mullard	OC 36
VT7	Transistor		Mullard	OC 139
VT8	Transistor		G.E.C.	GET 874
VT9	Transistor		G.E.C.	GET 874
VT10	Transistor		G.E.C.	GET 874
VT11	Transistor		Mullard	OC 139
VT12	Transistor		Mullard	OC 139
VT13	Transistor		Mullard	OC 84
VT14	Transistor		G.E.C.	GET 874
VT15	Transistor		S.T.C.	TK 31
VT16	Transistor		Mullard	OC 36
VT17	Transistor		Mullard	OC 36
VT18	Transistor		Mullard	OC 36
VT19	Transistor		Mullard	OC 139
VT20	Transistor		G.E.C.	GET 874
VT21	Transistor		G.E.C.	GET 874
VT22	Transistor		G.E.C.	GET 874
VT23	Transistor		Mullard	OC 139
VT24	Transistor		Mullard	OC 139
VT25	Transistor		Mullard	OC 84
VT26	Transistor		Mullard	OC 84
MR1	Germanium Diode		Texas	IS 130
MR2	Germanium Diode		Texas	IS 130
MR3	Germanium Diode		Texas	IS 130
MR4	Germanium Diode		Texas	IS 130
MR5	Germanium Diode		Texas	IS 130
MR6	Germanium Diode		Texas	IS 130
MR7	Zener Diode		B.T.H.	MR33H
MR8	Zener Diode		Mullard	OAZ 203
MR9	Zener Diode		Mullard	OAZ203
MR10	Zener Diode		Brush	Z5.6
MR11	Silicon Rectifier		Lucas	DB 506
MR12	Silicon Rectifier		Lucas	DB 506
MR13	Silicon Rectifier		Lucas	DB 506
MR14	Silicon Rectifier		Lucas	DB 506
MR15	Silicon Rectifier		B.T.H.	SJ052F
MR16	Germanium Diode		Texas	IS 130
MR17	Germanium Diode		Texas	IS 130
MR18	Germanium Diode		Texas	IS 130
MR19	Germanium Diode		Texas	IS 130
MR20	Germanium Diode		Texas	IS 130
MR21	Germanium Diode		Texas	IS 130
MR22	Zener Diode		B.T.H.	MR33H
MR23	Zener Diode		Mullard	OAZ203
MR24	Zener Diode		Mullard	OAZ203
MR25	Zener Diode		Brush	Z5.6
MR26	Silicon Rectifier		Lucas	DB 506
MR27	Silicon Rectifier		Lucas	DB 506
MR28	Silicon Rectifier		Lucas	DB 506
MR29	Silicon Rectifier		Lucas	DB 506
MR30	Silicon Rectifier		B.T.H.	SJ052F

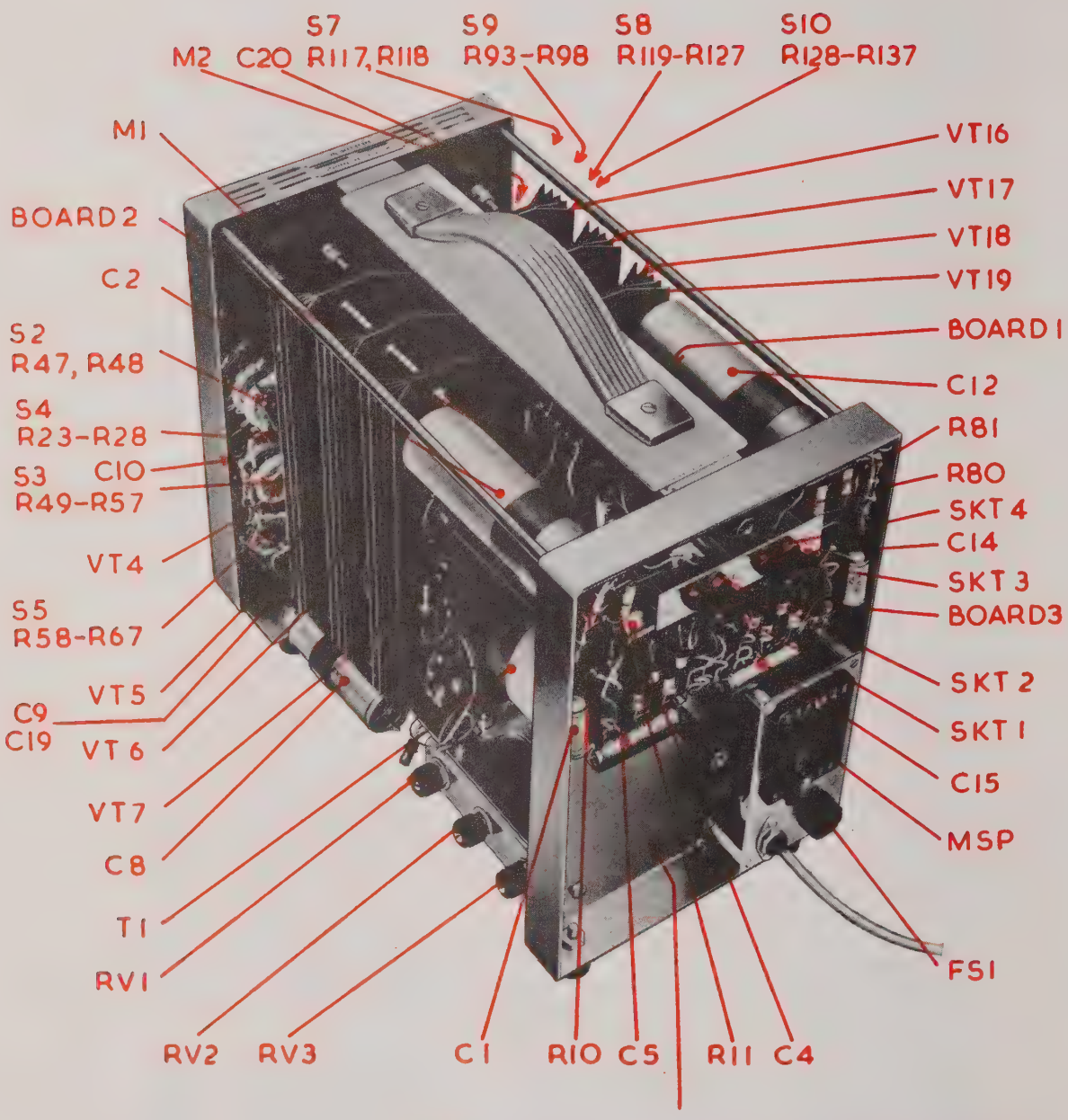
MISCELLANEOUS.

Circuit Ref.	Description	Solartron Part No.	Manufacturer & Type	
F1	Fuse Miniature 2.5A		Belling & Lee	L562
T1	Transformer	295098		
LP1	Lamp 6V 0.36W		Vitality	22
LP2	Lamp 6V 0.36W		Vitality	22
LP3	Lamp 24V 1W		Vitality	LES
LP4	Lamp 24V 1W		Vitality	LES
M1	Meter 0-1A	341065	Sifam Wessex	M21
M2	Meter 0-1A	341065	Sifam Wessex	M21
S1	Switch Toggle DP on/off 3 A	276224		
S2	Switch Wafer	261214		
S3	Switch Wafer	261215		
S4	Switch Wafer	261216		
S5	Switch Wafer	261219		
S6	Switch Toggle SP on/off	276124		
S7	Switch Wafer	261218		
S8	Switch Wafer	261217		
S9	Switch Wafer	261216		
S10	Switch Wafer	261210		
S11	Switch Toggle SP on/off	276124		
S12	Switch Wafer	261220		
MSP1	Selector Panel	297002		
TL1	Terminal Red		Hirschmann	PKi 10 A
TL2	Terminal Black		Hirschmann	PKi 10 A
TL3	Terminal Red		Hirschmann	PKi 10 A
TL4	Terminal Black		Hirschmann	PKi 10 A
TL5	Terminal Screw	AO.61316		
	Terminal Pillar	AO.61317		
SK1	Socket 4mm Red		Belling & Lee	L1413
SK2	Socket 4mm Black		Belling & Lee	L1413
SK3	Socket 4mm Red		Belling & Lee	L1413
SK4	Socket 4mm Black		Belling & Lee	L1413

Note : Equivalent components by other manufacturers may be fitted in some instruments.

Abbreviations :

S.T.C.	Standard Telephones & Cables
T.C.C.	Telegraph Condenser Company
G.E.C.	General Electric Company
W.W.	Wire Wound
H.S.	High Stability
Pa.	Paper
Po.	Polystyrene
M.P.	Metalised paper
M.Pl.	Metalised plastic
Ce.	Ceramic
El.	Electrolytic
M.F.	Metal Film
O.F.	Oxide Film



Note:
Diodes MR11-14, and MR26-29 are mounted on brackets (refer Fig. 10) and located in this area of the rear panel. On earlier instruments these components are fitted on group board No 3.

Figure 7. Components Location (Rear View).

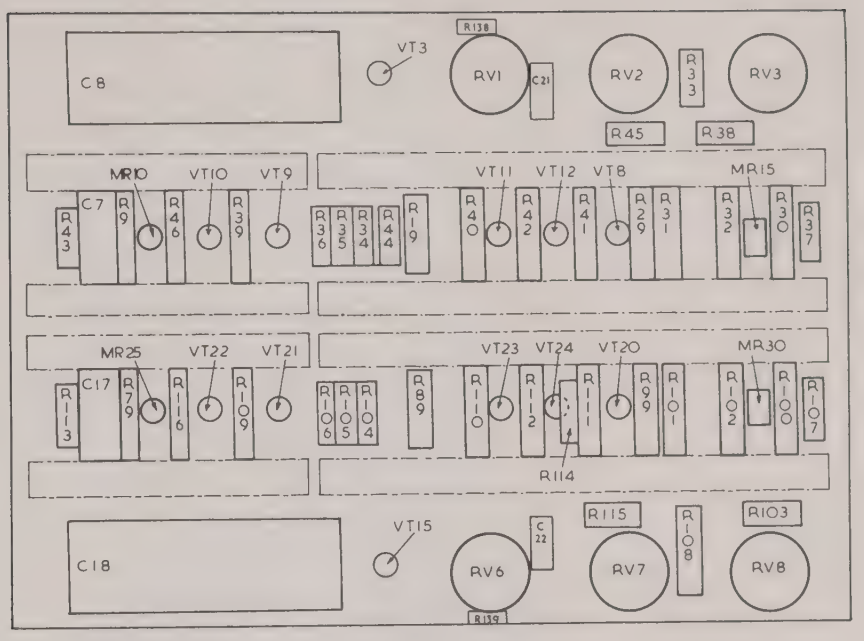
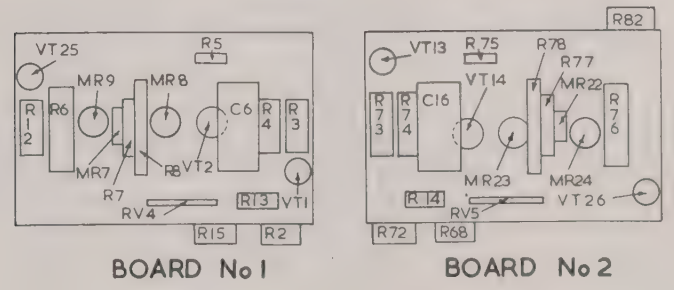


Figure 8. Components Location (Underside View).



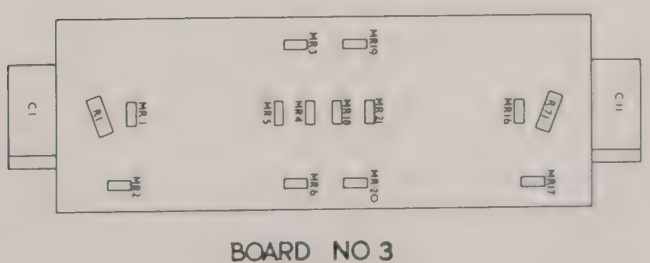


Figure 9. Components Location (Group Boards 1, 2 and 3).

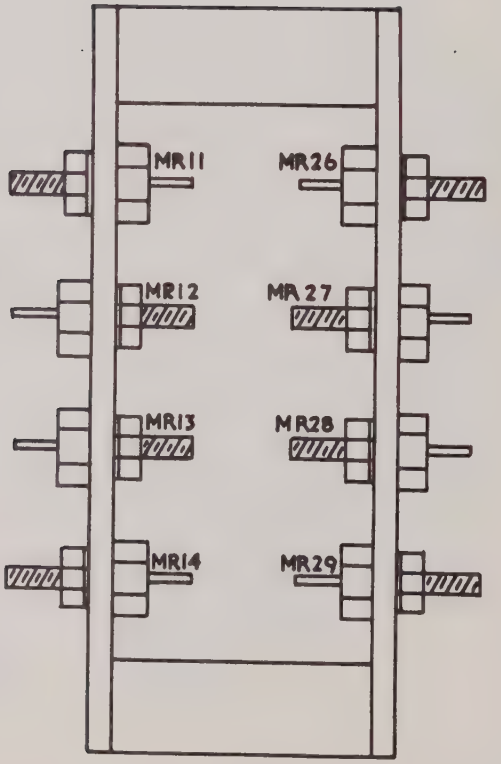
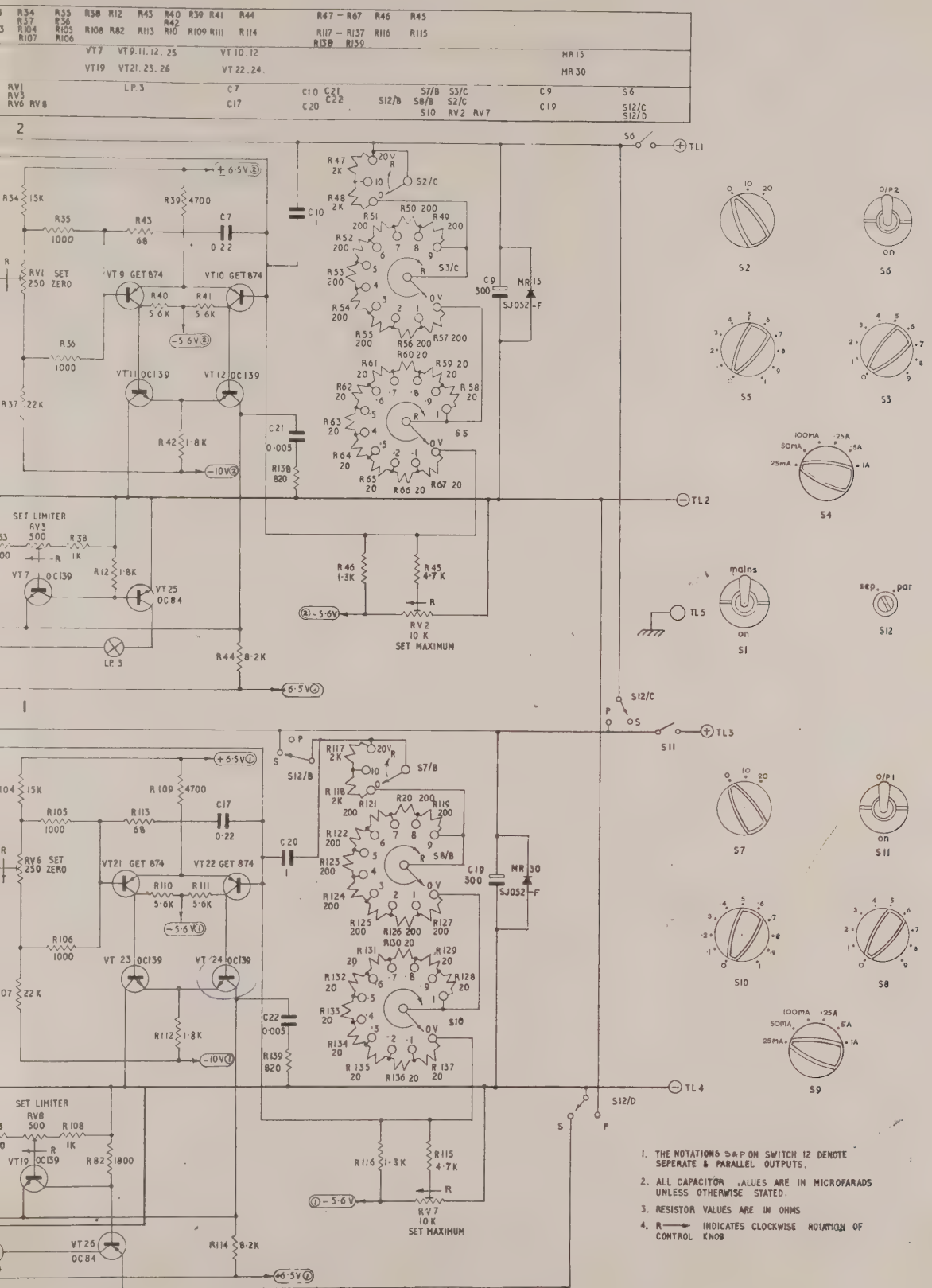


Fig. 10 Components Location (Board No. 4)



1. THE NOTATIONS S&P ON SWITCH 12 DENOTE SEPERATE & PARALLEL OUTPUTS.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE STATED.
3. RESISTOR VALUES ARE IN OHMS
4. R ⟶ INDICATES CLOCKWISE ROTATION OF CONTROL KNOB

Fig.11. Circuit Diagram AS 1164

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